Wageningen University and Research centre

Your partner for sustainable development in the Arctic

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1. Summary

Reduction of sea ice coverage
Most emphasis in the discussions on climate change has been on one of the consequences of global warming: global sea level rise. A major issue, however, has long been disregarded: the reduction of sea ice coverage of the Arctic seas. This is an issue with two sides: on the one hand a unique and very sensitive ecosystem is reduced in size very drastically, while on the other hand an enormous economic potential has become available.
The two most recognised economic challenges are the development of the large potential of oil and (mainly) gas reservoirs in the extended continental shelf in the Arctic and the availability of an East-West shipping lane (as trailed many years ago by the Dutch explorer Willem Barentsz.). Furthermore a huge area will become available for extension of the current pelagic fisheries and the northern coast of the continents will become available as export routes for goods from the Arctic region. Such export routes will increasingly grow in importance once existing transport routes (roads, railways and pipelines) are damaged due to the disappearance of permafrost.

The Arctic challenge: economy vs. ecology
It is obvious that with changing environmental conditions, local communities will need to change their accustomed way of living in order to survive. It is to be expected that these communities will attempt to benefit from the economic potential that is now to become unlocked. Without significant regional development there is great chance of failure, with possibly important social and ecological consequences as history has shown (Denmark's concentration of people along the Greenland coast).
The arctic ecosystem is very sensitive in nature, due to the high seasonal differences in light and temperature. The effective biologically productive season is short and therefore natural systems are easily disturbed and require long periods for recovery. The arctic seas are a refuge for many fish and whale species, while in the meantime serve as an important source of food and (thus) nursery area. The arctic tundra's are essential in the life cycle of many migratory bird species, which may be disrupted by only small changes. Additionally the contribution of greenhouse gases from the disappearing permafrost can be substantial.
The activities that form the economic potential of the arctic region imply a strong interaction with this sensitive ecosystem. Delicate development of this potential is therefore essential and the local communities may play an important role in this development.

Arctic claims
Following discovery of the Arctic by world renown explorers such as Barentsz (1596) and Peary (1909), two Russian submarines placed Russian flags on the arctic seabed, approximately 4000 m below the North Pole. Several expeditions were undertaken to prove that the continental shelf extends beyond the Exclusive Economic Zone, as this would imply exclusive rights for the exploration of the natural resources. However, other arctic nations such as Norway, US and Canada do not respect these Russian claims.

Arctic opportunities
The arctic challenge was described above as the regional development of rapidly changing environmental conditions in local communities. There are, however, also obvious opportunities for the Dutch economic sector. The most important of these are:

Offshore and maritime sector
Development of the arctic region for oil and gas production, as well as possible other resource extractions will require a fast amount of goods and services that are adapted to the extreme arctic conditions. This is a direct opportunity for the Dutch offshore and maritime sector, as fossil fuel extraction in the shallow North Sea has almost come to an end. Shipbuilding as well as dredging and offshore services may profit significantly from these new developments.

Rotterdam harbour
As soon as the North-West passage (a 7000 km shortcut between East-Asia and the Atlantic seaboard) becomes widely available, the role of Rotterdam Harbour may change dramatically as Rotterdam will become the most important hub towards the new passage.

Export of Agricultural goods and services
Sustainable regional and spatial development of the arctic regions mentioned earlier will require innovative ideas and needs to be supported by outstanding knowledge and front-end equipment. The Dutch agricultural sector should be capable of supporting this need for local food supply chains, better than any other European country Additionally the concept of (metropolitan) food clusters may provide an integral approach for production, logistics and social aspects.

New fishing grounds
Due to the decrease of the ice coverage in the arctic region, a significant area of fishing grounds will become available. In these deep waters pelagic fisheries may find an important economic potential of new fish stock. It is obvious that new commercial fish stocks should be exploited sustainably and it should therefore be considered a direct opportunity for the Dutch pelagic fisheries, since the Netherlands is frontrunner in the field of sustainable fisheries.

Spatial planning and design
Wageningen UR has a long tradition in spatial planning and all elements that are required to do this in an integral and sustainable way. GIS data analysis, landscape design, planning, the juridical framework and governance are all vital parts in sustainable planning.

The Wageningen Approach
The Arctic Challenge requires a multitude of expertise, from innovative technology to social and economic excellence. Wageningen University and Research centre comprises many of the required expertise in research and education and is a key player in the national and international networks that are needed to acquire complementary expertise. Wageningen UR has expressed to ambition to become an active player in the arctic regional and spatial development and is prepared and equipped to take the lead if necessary.

Next steps
The primary focus in the Wageningen Arctic Challenge is on Norway and Russia, mainly because of the excellent relation with institutes and authorities in the arctic regions of these countries. However, where opportunities excist, Greenland, US and Canada will be included.

In order to further describe the opportunities in the Arctic a 'position paper' is being developed. This paper is the basis for contacting the national and international network. This round of consultations is scheduled to be finished before summer, leading to a list of concrete actions.
Autumn 2011 is reserved to carry out the actions as formulated. First results will be presented at Arctic Frontiers, a leading conference in Tromso, January 2012, and at Arctic Murmansk International Forum, an annual Arctic conference in Murmansk, October 2011. It is the intention to prepare for a Dutch delegation consisting of interested public and private partners as a first milestone towards a shared Arctic Challenge.

2. Opportunities for the Arctic region

Introduction
This position paper explores new claims in the Arctic region. These claims are closely connected to new developments in the region such as climate change and the utilisation of natural resources. The aim of the paper is to illustrate how Wageningen University and Research centre contributes to sustainable development in the Arctic.

Arctic claims
In 1596 the Dutch explorers Barentsz and Van Heemskerk left with two ships to the North Pole. Their aim was to find a north-east route to Asia. The two ships stranded in the Arctic ice, forcing the crew to adapt to the Arctic environment and survive on the island of Nova Zembla in the north of Russia. Tragically Barentsz died on the way home (Hermans 1951). More than 400 years later, his dream might become reality with the Barentsz Sea becoming ice free, literally opening the route to new Arctic claims.

A new phase in the era of Arctic claims started in 1908, when Cook claimed he was the first to reach the North Pole. One year later Peary also claimed that he was the first to reach the North Pole. Both claims are disputed but Peary is generally seen as the first human being to set foot on the North Pole (McGhee 2007).

Yet another phase in the history of Arctic claims began in 2007 when two Russian submarines placed several Russian flags on the Arctic seabed, more than 4000 meters below the North Pole. One expedition after the other followed in order to prove that the continental shelf extended beyond their Exclusive Economic Zone. This would imply exclusive rights for the exploitation of natural resources (Yenikeyeff & Krysiek 2007).

Apparently Arctic claims are part of our common history. However, the nature and intensity of Arctic claims is changing.

Challenges
The Arctic is comprised of territories governed by eight countries — Russia, Canada, the United States, Norway, Denmark (including Greenland and the Faroe Islands), Iceland, Sweden, and Finland. At present, the territory and boundaries of the Arctic are not legally defined, and no legally binding treaty exists for managing the region as a whole (The Arctic 2011). The Arctic is a highly sensitive and vulnerable region both an environmental as from a social perspective. Future developments, driven by new claims, need to be implemented with the greatest possible care. This applies to all activities that are currently taking place. With even greater caution it also applies to new activities in the future.

New activities might involve new opportunities but also new threats. Mining for valuable minerals and the exploitation of oil and gas fields can become major economic drivers in the Arctic region. The US Geological Survey recently estimated that 30 per cent of the world's undiscovered gas, and 13 per cent of the world's undiscovered oil is located in the Arctic Region. The absolute numbers are even more stunning: 83 billion barrels of oil, enough to meet current global demands for three years and 44 trillion cubic metres of natural gas, or fourteen years' worth of supply. The US Energy Information Administration reported in 2009 that the exploitation of these resources involves considerable risks. This relates to unsolved resource claims, harsh environmental

conditions but also to consequences to the Arctic environment. In order to cope with new risks of petroleum activities Oil Spill Response Systems will be crucia (Gautier 2009; Bloomberg 2010; Byers 2010)l.

New shipping routes also play an important role here. The Northwest Passage has the potential of a 7,000 kilometre shortcut between East Asia and the Atlantic Seaboard, compared with the usual route through the Panama Canal. Hundreds of ice-strengthened vessels are already being built in Finland and South Korea. Many of them are dual direction vessel, sailing normally and efficiently in open water. In the ice these vessels are able to turn around and use their propellers to crush the ice. Again, new opportunities cause new threats. According to the Arctic Marine Shipping Assessment from 2009 the most significant threat from ships to the Arctic marine environment is the release of oil through accidental or illegal discharge. Additional potential impacts of Arctic ships include ship strikes on marine mammals, the introduction of alien species, disruption of migratory patterns of marine mammals and anthropogenic noise produced from marine shipping activity (Byers 2010; PAME 2009).

New shipping routes are again connected to the development of infrastructure such as harbours and coastal defence. Existing infrastructure might not have enough capacity for these new activities. At the same time this infrastructure can become subject to higher sea levels in relation to climate change. Arctic agriculture, fishery and tourism could become new resources for coastal communities. However this might require adaptation to new environmental circumstances and thus new lifestyles (Knol 2011; Bergh 2011).

Taken together there are many public and private stakeholders involved with their own competing claims. Coordination and organisation of these claims in order to minimise conflicts and maximise cooperation is a huge challenge. Arctic knowledge might prove to be crucial in dealing with the challenge of developing controversial activities in a highly vulnerable region.

Norway

Climate change might become one of the driving forces behind new developments in Norway. The melting ice opens up new fishing grounds for Norwegian fisheries, increasing opportunities for higher incomes. Higher sea water temperatures can involve a higher density of plankton, resulting in increasing fish populations. With new opportunities new threats might also appear, such as overexploitation of resources. Arctic ecosystems are highly vulnerable. To steer this development in a sustainable manner the Norwegian government could further develop policy instruments such as zoning. Norway is also considered as a leading country in aquaculture. For years Norway is the number one producer of salmon and trout. In recent years cod farming has also been developed. Climate change might have positive effects such as faster growth of fish due to slightly higher water temperatures. At the same time bacteria and diseases might develop and spread faster due to these higher temperatures (Knol 2011; Bergh 2011).

The Sami people are the indigenous people of approximately 75,000 individuals, inhabiting parts of Norway, Sweden, Finland and Russia. The Sami are semi-nomadic living from coastal fishing and reindeer herding. They hold exclusive fishing and herding rights. In Norway, Sweden and Finland this ethnic group has their own parliament, called the Sameting, which was established in 1987. The implications of climate change for the Sami can be vast. The permafrost of the tundra is crucial as a feeding source for

reindeers. When tundra's change into swamps, the reindeers will simply starve. On the other hand there might be new opportunities for the Sami, such as agriculture and tourism. However this involves huge implications for their traditional livelihood (Josefsen 2007).

Climate change also affects Norway's vast hydroelectric infrastructure. On the European level Norway is the biggest hydro power producer. Currently there are approximately 860 power stations in operation, producing more than one million MWh. In total 99% of Norway's power production comes from hydro power. The supply of electricity follows a strict pattern. Demand for electricity is lower in summer, causing the surplus to be exported. During winter demand for electricity is higher. However electricity production is lower due to frozen rivers, causing the shortage to be imported. A changing climate can also change this pattern resulting, again, in new opportunities and/or new threats (Andersen 2006; Bergh 2011).

Current sea level rise can form a threat to existing Norwegian infrastructure such as harbours and coastal defence. In 2010 a report of the Directorate for Civil Protection and Emergency Planning estimates a rise of 40-80 cm between the year 2000 and 2100. The land will also rise in the same period, however at a slower pace than the sea level. These estimates have huge implications for some 250 coastal communities. The implications are of such a national importance that the Norwegian government decided to establish the Norwegian Climate Change Adaptation Programme. This programme aims to strengthen knowledge on adaptation to climate change and exchange of information between sectors and administrative levels (BSD 2011).

Tourism accounts for 4% of Norway's GDP and is an important means for local community livelihood in the north (WTTC 2011a). Norway receives around 4 million international tourists per year, many of whom are known to visit Norway for its scenic beauty and activities in terrestrial and maritime environments (Innovation Norway 2006). Over the last decades, visitation to attractions in Northern Norway, such as the North Cape and the Lofoten, has grown significantly. Likewise, the Arctic archipelago of Svalbard attracts an estimated 36,000 land-based tourists, and an additional 30,000 tourists by cruise ship (Guðmundsdóttir and Sæþórsdóttir 2009). These numbers have more than doubled in the last decade (Lamers and Amelung 2010). What the effects are of these developments, how compatible tourism is with activities like oil and gas exploitation, and how global environmental change will affect the Norwegian and Svalbard tourism sector and its local communities is largely unknown (Lamers and Amelung 2010).

The oil and gas industry of Norway ranks as the world second largest. At the end of 2010 the country produced 1.9 million barrels of oil and 9.3 billion cubic meters of gas per day. In 2008 the petroleum sector contributed to 34 per cent of the state's income and 50 per cent of its export value. To maintain production levels it is crucial to exploit new fields. Moreover, gas exploitation in the near future is expected to rise even further whereas oil exploitation is expected to decline. To steer the petroleum exploitation the Norwegian government introduced an Integrated Management Plan in 2006. It involves spatial planning including closed areas and specific zones for petroleum activities. Norway also cooperates with Russia with respect to petroleum activities. The reason is simple; Norway's techniques and infrastructure are of a higher level both in quantity as in quality

(Norwegian Government 2006; Gautier 2009; Bloomberg 2010; Knol 2010a; Knol 2010; Knol 2010; Knol 2011).

Russian Federation

The Arctic zone of the Russian Federation is understood as the part of the Arctic which includes, either fully or partially, the territories of the Republic of Saha (Yakutiya), Murmansk and Arkhangelsk regions, Krasnoyarsk Krai, Nenets, Yamalo-Nenets and Chukotka Autonomous Okrug[1].

In recent years, the Russian leaders clearly emphasize that the Arctic region is of strategic importance to the Russia's wealth and competitiveness on global markets. Only 2 percent of the Russian population lives in the Arctic, but the region stands for 14 percent of Russia's GDP and 25 percent of the country's export. The Russian Arctic holds 80 percent of Russia's natural gas, 90 percent of nickel and cobalt and 60 percent of copper. In addition, there are probably vast undiscovered resources under the sea bottom in the Polar Sea (Basargin, 2010).

Russia is the last of the countries with access to the Arctic to develop a strategy for Arctic development. The strategy proposal was presented at the second Arctic Murmansk International Economic Forum in Murmansk (Ministry of Regional Development of the Russian Federation, 2010). The strategy was expected to be adopted by the end of 2010. To date there is no official information on the adoption of this strategy. According to this strategy, the following driving forces influence the Arctic development in Russia:

1. Rich natural resources (especially, hydrocarbons such as gas and oil) is the main driver. The Shtokman gas field in the Barentsz sea will be first Arctic offshore field in production, an on-going joint project of Gasprom (Russia), Total (France) and Statoil (Norway). Shtokman is one of the biggest offshore gas fields in the world and a major driving force for future Russian economic activity in the Arctic.
   The strategy introduces a new approach to exploration of natural resources in the Arctic by turning the focus to use of resources instead of preserving them to coming generations as was argued earlier (sustainable use in place of the conservation).
2. New shipping route, modernization/opening the "Northern See Route" for commercial international navigation as a wholly integrated transportation link and a central element in maritime connections between Europe and Asia, mainly in connection with growing extraction of the Arctic's natural resources.
3. As a prerequisite the development of modern Arctic harbors, with appropriate infrastructures and the acquisition of new nuclear-powered icebreakers. Most of the existing harbors were privatized in 1990s but were not well maintained.
4. Strategic importance: the Arctic region hosts the Russian naval and aviation patrol routes, and one of the next goals is to establish special Arctic military formations in order to protect the county's national interests[2] in various military and political situations

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[1] A defined by the decision of the Government Commission on Arctic Issues under the Council of Ministers of the USSR on April 22, 1989.

[2] "national interests of the Russian Federation" – the aggregate of internal and external needs of the state in ensuring the protection and stable development of the individual, society and the state, as defined by the Russian National Security Strategy until 2020 (Security Council of the Russian Federation, 2009).

5. International collaboration of the polar countries in the development of the off-shore oil and gas deposits, which may depend on accommodating foreign investments. Collaboration can also occur with regard to ecological and military activities.
6. Environmental issues, including development of tourism and creation of national parks and reserves.

Preparations for challenges that may derive from economic and other activities define three priorities of Russian policy in the Arctic. The first priority is the creation of top-quality, comfortable living conditions for local people and the pursuit of a frugal attitude towards the indigenous Arctic nations' socio-economic infrastructure and traditions. The second priority is the support for new economic-growth points and incentives for domestic and foreign investments, following the most stringent environmental requirements. The third priority is substantial investment in the scientific and nature-conservation infrastructure, including a serious spring-cleaning of the Arctic territories from the garbage and creation of new national parks and reserves (Putin, 2010).

New forms of Arctic governance and collective actions of all stakeholders for successful implementation will include state support and creation of favorable investment climate for attracting business on the basis of public-private partnership.

It is foreseen development of new city agglomerations in the Arctic zone, caused by development of transport systems, logistic centers, education and innovation centers, such as Murmansk, Norilsk, Arkhangelsk, Chaun-Bilibinsk, Anadir, Salekhard, Noyabr, Noviy Urengoy – Nadim agglomerations. The expected development is in line with a concept of spatial development in Russia as part of the Concept of Long-Term Socio-Economic Development of Russian Federation for the period until 2020 (The Ministry for Economic Development of the Russian Federation, 2008).

According to the strategy for Arctic development (Ministry of Regional Development of the Russian Federation, 2010), the Arctic development in Russian Federation is to be largely stimulated by two groups of so-called megaprojects. The first group focuses on integration of the Arctic Zone with other regions; main activities are to be related to development of the transport infrastructure. The second group focuses on the Arctic Zone itself; main activities are to be related to gas and oil exploitation. Besides these megaprojects, priorities of the social-economic development also include creating favourable conditions for modernization of other major industries in the Arctic Zone. These are mining industry, fishing industry and agriculture. The rest of this section shortly describes the priorities related to these industries as Wageningen UR expertise can contribute substantially to their development in the Arctic Zone in general and in the regions of Murmansk and Arkhangelsk as European part of the Russian Arctic Zone.

In general, fishing industry is the third industry (after gas exploitation and mining industry) in the Arctic Zone in Russia. About one third of the Russian fish and other marine products is caught here. About 20% of fish canned foods are processed here. The Barentsz Sea and the Bering Sea have the most rich fish resources. Due to climate changes increase in marine bio-production is expected in the Kara Sea.
Modernization of the fishing industry is to include improvement of production, catch, processing and realization of marine (water) bio-resources and imply production of more value added products and maximum resource utilisation.

At the moment, only about one third of the Arctic food supply needs is produced locally. Most of the necessary food products (according to basic diet requirements for regions with extreme weather/nature conditions) are supplied from other regions, which is cost-inefficient. Thus, development in agriculture is to focus more on production and processing of basic food products in local value-added supply chains. This should improve the living conditions of people living in the Arctic Zone.
Also, education (in particular professional education) should help prevent migration of young people out of the Arctic Zone and attract new people to the region.

Other priorities are the development of facilities for small-scale energy production (windmills[3], geothermal sources, and others) along the Northern See Route, the development of innovation infrastructure as basis for innovation processes. Pilot projects, techno-parks, business-incubators, knowledge transfer centres.

Both Murmansk and Arkhangelsk regions are so-called "old industry" regions, development of which started more than 75 years ago. These are regions with rather developed human capital (incl. research and education schools). At the same time, these are regions with many mono-specialised towns and conservative government, which is considered as barrier to innovative development.
Both regions have a low aboriginal population (1-1.5%), with no favourable conditions for keeping aborigines' language, low incomes (half of the minimum requirement), high barriers for use prestacions socials and other goods due to remote locations.

Specifics of Murmansk
Industrial sector of Murmansk is formed be the presence of few large resource corporations. The success of development will depend on successful collaboration of local governments and business. Fishing industry is foreseen to stimulate development of diverse industries related to fishery: construction new ships with the fridge equipment, new technologies of catching and processing including modern technologies of fish deep freezing and storage, etc.; aquaculture (also, fish auction is to be built); marine biotechnology in the future.
In the areas populated by the Sami people, establishing reindeer husbandry traditional for the Sami people is an important issue.
Construction of glasshouses for vegetables in Murmansk is another issue in the agricultural sector (personal communication with Trade Representative in the NL).

Specifics of Arkhangelsk
Arkhangelsk region is recipient of Federal Government Budget Funds. It is a very disperse region with small and average units/subjects and clearly needs direct participation of government in realization of activities described in the Strategy.
Forestry is one of the main drivers of the regional economy. Development in this industry is to focus on more advanced wood processing, production of more added value products and sustainable use of the forest resources.
Arkhangelsk region, together with other Russia' s Northwest regions, produce about 60% of the country's paper. The industries are big potential users of biofuels and suppliers of

[3] Windmills are used to be used a lot until 1970s.

biomass (residues from sawmills and the pulp and paper industry) to power generation companies and local utilities (Hansen et al., 2006).
The main development on the fishery industry is the ocean use of water bio-resources, fishery.

Greenland
With only 56,000 thousand inhabitants Greenland is as the largest island (not a continent) in the world the least heavily populated country. Over 80% of the surface is covered with the Greenland ice sheet.
This ice sheet makes short term developments a difficult task but on a long term valuable natural resources (oil, gas, uranium) are present.

The economy remains critically dependent on exports of shrimp and fish and on a substantial subsidy - about $650 million in 2009 - from the Danish Government, which supplies nearly 60% of government revenues. The public sector, including publicly owned enterprises and the municipalities, plays the dominant role in Greenland's economy. Greenland's GDP contracted about 2% in 2009 as a result of the global economic slowdown. Budget surpluses turned to deficits beginning in 2007 and unemployment has risen. During the last decade the Greenland Home Rule Government (GHRG) pursued conservative fiscal and monetary policies, but public pressure has increased for better schools, health care and retirement systems. The Greenlandic economy has benefited from increasing catches and exports of shrimp, Greenland halibut and, more recently, crabs. Due to Greenland's continued dependence on exports of fish - which account for 82% of exports - the economy remains very sensitive to foreign developments. International consortia are increasingly active in exploring for hydrocarbon resources off Greenland's western coast, and international studies indicate the potential for oil and gas fields in northern and north-eastern Greenland. In May 2007 a US aluminium producer concluded a memorandum of understanding with the Greenland Home Rule Government to build an aluminium smelter and a power generation facility, which takes advantage of Greenland's abundant hydropower potential. Within the area of mining, olivine sand continues to be produced and gold production has resumed in south Greenland. Tourism also offers another avenue of economic growth for Greenland, with increasing numbers of cruise lines now operating in Greenland's western and southern waters during the peak summer tourism season.

Quotes from an interview with Kuupik Kleist – prime minister (BBC Hard Talk - 2010)
"I don't understand these Europeans. I mean, why don't they worry about their own stuff back home?" he said. "In the first place, you might have noticed that the last actions carried out by Greenpeace were not very popular in Greenland, and everybody who has a little bit of insight into what is going on around the world thinks that what Greenpeace is doing these days is purely a question of promoting the organization itself. … We are capable of taking care of the environment ourselves."
Still, he acknowledges, the Nuuk government, only a year old, has only just passed the laws necessary to ensure environmental regulation and oversight of oil drilling, and doesn't possess the resources to enforce and inspect the operations.
"We are very much aware that we need to build up our capacity in [environmental regulation]," he said, "and we don't claim to be experts at all, but we are doing our best, and we are aware of the threats and the risks, and global debate on this."

And, he says in a moment of reassurance, the oil hasn't started flowing yet. Nor has the uranium begun emerging from the ground, after his parliament authorized uranium exploration last week; the vast wealth of resources believed to be trapped under Greenland, increasingly accessible in an era of global warming, remains a future promise. "We haven't earned one single kroner yet! Independence is something we need to prepare for, and we've set up an oil fund so we can be like Norway when it comes," he says. "But independence isn't something that can just appear, from the top down. We need to get ourselves prepared for it. And one day, I'm sure that the desire and the wish will be so strong that you cannot hold it back any more, and then we will become a country."

Social transitions - problems
Within three generations, the Inuit have undergone a sharp transition from igloos to houses, dog teams to airplanes, and storytelling to TV and the Internet - at enormous social costs. The suicide rate among the Inuit is eleven times the Canadian average with most of the victims being directionless young men who, just a few decades ago, would have been providing for their families "on the land". The melting ice has become part of the problem, sometimes stranding those who still venture out and even claiming their lives as they plunge through thin and weaked patches. Across the Arctic, Inuit hunters striving to maintain their independence and cultural identity are paying the ultimate price.
With rapidly changing ice conditions the Inuit will probably have to go through another, maybe this time possibly even more dramatic, major shift. Participation in sustainable development in the region is essential for preventing another social crisis.

Iceland

Iceland's Gross Domestic Product (GDP) is primarily based upon three sectors: agriculture contributes 6%, industry (such as hydropower and aluminium smelts about 20% and (financial) services 70%. Tourism makes up the last 4%.

Agriculture
Iceland is an island that lies above the 620 latitude, with average temperatures of around 10C in July. The island is young on the geological calendar, consisting almost exclusively of volcanic rocks, lava and sediment and has still many active volcanoes. The arable land below 200 m altitude (land that can be cultivated), partly vegetated and partly barren, represents 15% of the total surface, 18% of the area lies between 200 and 400 m and 54% above 400 m altitude. Population density in several regions is less than 3 persons per km2, restricting the development of local markets, and consequently, implying that distances to the latter are long and transports of agricultural products and inputs, become costly.

It is evident from the aforementioned data that Iceland is not very favourable to agricultural production and by consequence the farmers' revenues are strongly dependant on coupled payments and high import tariffs. Even though agriculture's contribution to GDP is 1.4% and only 3% of the total workforce is employed in agriculture, the agricultural sector plays an important role, as it is the backbone for employment and livelihoods of its scarcely populated parts of the country and the

Icelandic society is ready to support the existing 3,045 operational farms (2006). It is worth to be highlighted that Iceland has one of the highest PSE (51%, in 2008) among the OECD countries, which is almost double than the EU one (25%, in 2008).

Traditional agriculture is primarily based on grass, by natural pasturage and making fodder in the form of hay or silage from cultivated grass fields. Total cultivated grassland amounts to 120,000 hectares. Crop production is currently on small scale, almost exclusively barley for feed for use on the farms and not for sale. This cultivation, however, has been increasing rapidly in the last few years and barley is now grown on over 4,000 hectares yielding around 15,000 tonnes and provides around 10% of all grain used for livestock feed.

Livestock production accounts for 87% of the farm income. An average dairy farmer has around 30-40 milk cows and a sheep farmer 300-600 sheep. The remaining share of the income derives from horticulture. The latter is mainly limited to the production of potatoes, turnips, cabbages, cauliflower and carrots, which are cultivated outside and to tomatoes, cucumbers, peppers, nursery plants and flowers, which are cultivated in greenhouses based on geothermal energy and artificial lighting. Icelandic farmers have relatively large holdings, the total size of farms often being hundreds of hectares. Family farming is overwhelmingly the most common arrangement and in some cases two families work the same farm. Most farmers own their land and many farms have been owned by the same families for centuries and almost all farmers are affiliated to a sectoral organization, all together forming one single association called - the Farmers Association.

Rural development policy does not exist as such in Iceland. However, one might compare the European rural development policy with Icelandic regional development policy, which has some quasi-similar objectives. Icelandic regional development policy is not attributed only to one ministry; instead all the ministries and certain additional institutions are involved in rural development.

Fisheries

The export of fish products still weighs considerably in the nation’s foreign currency earnings, the following are the 2008 numbers; 37% of merchandise exports, roughly 26% of total exports and 8% of GDP.

In 2008 the total catch in Icelandic waters was close to 1.3 million tonnes of fish products worth ISK 171 billion; EUR 1.4 billion in export value. At the same time, the nation’s total population was 319,000 people and the workforce 178,600. The fishing industry employs 4.1% of the total workforce; fishing 2.4% and fish processing 1.7%. Although not visible from the aforementioned numbers, the fishing industry is fundamental for the whole economy and the country’s regional development. Fisheries and fish processing companies constitute the most important source of livelihood in coastal communities, where employment opportunities are often more limited because of less economic diversification.

Services

Mainly financial services have been an important sector in Iceland’s economy until the recent global financial crisis. Iceland has been hit severely by this crisis and is still

working on solutions. The new role the country will play in the future global financial world remains to be seen.
Internet technology is another sector within Iceland's services sector. Already Iceland hosts a large number of ICT companies ranging from software development to database and internet hosting. In this last field Iceland may be an important future player with green energy (hydropower), low average temperatures (less energy needed for cooling data servers and its strategic position between United States and Europe.

Tourism
In 2008 around 500.000 international tourists visited Iceland by aircraft and 30.000 by cruise ship. Direct incomes from tourism make up 4.6% of the GDP and holds a total of 8,000 jobs. These numbers are expected to grow in the coming years (WTTC 2011b). Tourism represents an important alternative source of livelihood in coastal and inland communities. Whether the effects of climate change presents a threat or an opportunity for the tourism sector in Iceland is largely unknown.

Emerging possibilities due to climate change?
Both fisheries and agriculture could benefit from climate change although active volcanism will remain an unpredictable factor especially for agriculture. Chances however emerge in the coastal lowlands, especially the large sandur plains in the South will become less prone to seasonal and volcanism-heat induced incidental flooding due to the facts that the land ice will become less voluminous.

Terrestrial ecosystems
The terrestrial ecosystems in the arctic are extremely sensitive for changes due to the fact that processes that create these systems evolve at a slow pace. Also these ecosystems are of major importance, not only for the arctic system but also linked to other (eco)systems on our planet. The effects of climate change in the arctic can for example be significant for bird migration routes, the development of large rivers and the emission of greenhouse gases from the tundra. Wageningen UR has developed expertise in the fields of bird migration and the role of the arctic for Geese. Large rivers in Russia (Pechora basin) and northern Canada (McKenzie delta) have been studied from an fysical-ecological point of view.

Marine ecosystems
The Arctic Ocean consists of a number of seas such as the Norwegian Sea, the Greenland Sea, the Barentsz Sea, the Kara Sea, the Laptev Sea, the White Sea, the East Siberian Sea, the Chukchi Sea, the Beaufort Sea and the Bering Sea (Google Earth 2011). The Arctic ocean covers an area of approximately 14 million square kilometres.

As in all oceans, the food web in the Arctic ocean is starts with phytoplankton. It releases oxygen, reduces CO2 and produces carbohydrates through photosynthesis. In the Arctic Ocean phytoplankton generally grows slower compared to warmer waters. However this relates mostly to limits in sunlight and nutrients, more than temperature. Phytoplankton is primarily consumed by zooplankton. Forms of algae and bacteria live below and in the cracks of the ice, withstanding temperatures of minus 22 degrees Celcius. Crustacean species feed on phyto- and zooplankton which is again eaten by fish. The latter serves as a food source for seabirds and seals. Finally the seals are the primary food for polar bears (Corell & Cleveland 2010; Byers 2010).

The Arctic benthos varies considerably with respect to biodiversity. The greatest numbers are found in the Barentsz Sea and Bering Sea and off the coast of West Greenland and Iceland. In the Barentsz Sea it is estimated that there are around 1,600 benthos species, in the Bering Sea this number rises to 2,000. Less species are found in the Laptev Sea with 365 species, relating to colder water masses and brackish conditions. The deep Artic Ocean contains even fewer benthic species varying from 0 to 11 (Corell & Cleveland 2010).

Fish species in the Arctic Ocean that are of commercial interest include cod, herring, pollock, redfish, halibut and flatfish such as plaice and sole. Cod has adapted well to Arctic circumstances. Through its production of anti-freeze proteins it can live in temperatures below 0°C. Severe fluctuations in fish populations have occurred in the 20th century. Between the 1920s and 1960s a warmer period caused an increase in the populations of a number of fish species. Cod populations on the other hand have been reduced to low levels due to increasing fishing intensity (Corell & Cleveland 2010).

Sea mammals include the polar bear, walrus, seal and whales. It is estimated that the polar bear population varies between 22,000 – 27,000. The polar bears' principal prey specie is the ringed seal. Due to melting ice polar bears have to swim longer distances in order to reach their food. Distances of 15 miles are not an issue; however when it comes to more than 60 miles there is a serious possibility of drowning. Considering walruses there are two main species, the Pacific and the Atlantic walrus. It is estimated that there approximately 200,000 walruses in the circumpolar area. More than 10 species of seals have been counted in the Arctic area, including the ringed seal, the bearded seal and the harbour seal. In total their populations number in the millions. However between species there are enormous differences. The population of ringed seals for example counts millions whereas the population of grey seals in Norway and Russia was recently estimated at 4,500. A number of whale species is common to the Arctic Ocean depending especially during summer. Examples are the white whale, bowhead whale, right whale, grey whale, blue whale, humpback whale, killer whale and several dolphin species such as the white-beaked dolphin and harbour porpoise (Corell & Cleveland 2010).

Seabirds are common in the Arctic Region. Over 60 species have been counted, with 40 species breeding in the area. Just as the whales many species take advantage of the summer productivity of the Arctic Ocean and overwinter elsewhere (Corell & Cleveland 2010).

Tourism

Tourism is developing rapidly in the European Arctic, as well as their North-American regional counterparts and the Antarctic (Lamers and Amelung 2010). In recent years, the increasing scale and changing structure of Arctic tourism has raised questions about the environmental and social sustainability of this development. Arctic tourism activities are operated by different types of organisations, in terms of size (e.g. individual entrepreneurs, multinationals), activities (e.g. land-based, ship-based) and origin (e.g. local, international). While tourism used to be an overseas operation, it is developing into an increasingly vital industry in the Arctic and creating opportunities for local entrepreneurs. Arctic tourism is predominantly nature-based, providing experiences for the cruise market, the nature-based or wilderness market, the adventure market and the culture and heritage market (Snyder 2007). Tourism is increasingly important for

creating sustainable community livelihood in Greenland, Iceland, and the Norwegian and Russian Arctic, and an alternative means of income for communities heavily dependent on natural resources. Contemporary tourism development can count on broad interest of the industry and authorities in the Arctic region, however besides new opportunities the development also represents challenges. The compatibility of nature-based tourism activities with other exploitative resource uses is insufficiently known. The Arctic region is facing rapid global changes including climate change. Questions of vulnerability, risk and adaptation require attention as tourism, if not managed properly, can become one of the stressors. Implementation of measures safeguarding environmental and social sustainability, nature protection, as well as human safety is gaining importance for potential tourists, businesses and authorities. How different types of tourism stakeholders respond and adapt to global environmental change and the associated risks is insufficiently known. For example, mobile actors (e.g. foreign cruise ship operators) can easily relocate their operations, whereas place-bounded actors (e.g. local hotel owners and operators) cannot. New conflicts of interest as well as new alliances may emerge between tourism businesses, local communities, governmental agencies, and other actors in the tourism sphere, as global environmental change unfolds. To assist in these developments a more thorough and detailed understanding is needed of the multiple actors that regulate tourist flows and impacts at different levels. As tourism is likely to feature in debates on risk and adaptation in the Arctic in the foreseeable future, it is timely to invest in key information, knowledge and policy tools for tourism management and international cooperation (Lamers and Amelung 2010).

3. Opportunities for the Netherlands

Introduction
The Netherlands has a long history in shipping, coastal infrastructure, marine logistics, sustainable fisheries and oil and gas exploration and production. With this outstanding experience Dutch public and private parties are important players in Arctic Development. Below we will try to give our vision on how the Port of Rotterdam can contribute to Arctic Development, how Dutch companies might assist in the construction of Arctic infrastructure, how the Dutch experience in sustainable fisheries might be utilised in the Arctic and last but not least how the Dutch experience in oil and gas exploitation might be of assistance in Arctic countries.

Port of Rotterdam
The Port of Rotterdam is highly strategically located, especially with respect to the Arctic and the Northern Sea Route (NSR). Moreover, from the top 10 largest ports, Rotterdam is situated closest to the NSR and will as such be an increasingly important hub towards the East. The 1,200 employees of the Port have a vast experience with worldwide logistics. Their experience can be of assistance for the planning of new harbours and the reconstruction of existing harbours along the NSR.

Rotterdam hosts one of the world's largest ports. Approximately 430 million tonnes of goods are annually transported through this port. These goods are transported by 34,000 ocean-going and 100,000 inland vessels. Over 90,000 jobs are directly associated with the Port of Rotterdam. Currently the Port is expanding its territory with another 1,000 hectares. Of course the project is carried in a typically Dutch manner; all land is being reclaimed from the North Sea (Port of Rotterdam 2011).

Coastal infrastructure
In the Arctic region coastal infrastructure will be the basis of further development. Without coastal defence, harbours and channels these developments will not succeed. The Dutch are more than willing to share their experience in coastal infrastructure.

In the field of coastal infrastructure, Dutch companies are among the most experienced in the world. On a national level the Dutch closed off the Southern Sea with the construction of a 30 km long dike in 1932. An artificial lake was created of 1,100 square km, reducing the Dutch coastline with 250 km. Within the new lake a whole new province was made in the 1960s, creating 1.400 square km of new land. As mentioned above, the Port of Rotterdam is currently expanded by approximately 10% (Wikipedia 2011a; Wikipedia 2011b; Port of Rotterdam 2011).

But there are also international success stories. These include the construction of a 12 square km island for the airport of Hongkong in 1997. In Dubai, a huge palm islands of was created in 2004, offering new space for 2,000 villas. In Saint Petersburg a Dutch company is involved in the construction of a large shipping channel, a tunnel under the channel and a large Flood Protection Barrier (Wikipedia 2011c; Wikipedia 2011d; Boskalis 2011).

Sustainable fisheries
As has been described in this position paper, climate change in the Arctic region might cause fish populations to increase. It is of utmost important that these new resources are utilised in a sustainable manner.

The Dutch have booked successes in sustainable fisheries through public-private partnerships. According to the Dutch Approach, the key to sustainability is innovation and the key to innovation is cooperation. The approach consists of three pillars. The first pillar is the Fisheries Innovation Platform. The aim of the platform is to encourage innovation for a sustainable and profitable fisheries sector. The second pillar consists of study groups. Currently there are 13 study groups in the Netherlands. Fishermen themselves are discussing challenges, questions and problems in order to find solutions. The third pillar is the European Fisheries Fund. With € 120 million between 2007 and 2013, innovation and cooperation projects are funded through tendering schemes. The Fisheries Innovations Platform acts as the assessment commission (Vermuë 2010).

Among the successes are the Sumwing as an alternative for the beam in beam trawling and the Pulse as an alternative for the tickler chains that are used with beam trawling. Recently these two techniques have been combined into the Pulsewing. The success of these technologies can be explained by severe fuel reductions of approximately 15%, CO2 reductions, and reduced effects on marine ecosystems.

Oil & gas exploitation
On the Dutch EEZ there are approximately 130 platforms in use. The majority of these platforms is used for gas exploitation. Only 10 locations are used for oil exploitation. In 2009 approximately 1.3 million m3 of oil and 23,000 million m3 of gas has been produced. Almost 20,000 persons are employed in this sector (Noordzeeloket, 2011; Ministerie van EZ, 2010).

Oil and gas reservoirs will be depleted in the next 10 to 15 years. New developments are sought in deep sea and arctic areas. The large gas reservoirs in the arctic seas and the vast experience of the Dutch in the exploitation of offshore gas reservoirs in an environmentally sustainable way opens opportunities for new partnerships. Furthermore, the Dutch offshore construction industry is among the most innovative in the world, capable as no other to tackle the challenges of the arctic.

Agricultural sector
The Dutch agricultural sector is one of the leading in the world not only as an export product (such as bulbs, flowers and seeds) but also in concepts and innovations connected to efficiency in production processes and logistics. Both types of export products cover a wide range of countries all over the world. This is a useful and strong base for exploring potentials for present and future arctic agricultural developments.

Realising opportunities for sustainable development
This chapter illustrates that the Dutch private sector is very capable of international large scale coastal projects. Moreover public-private partnerships, e.g. in fisheries have resulted in new technological innovations that are an essential means towards more sustainability. In the next chapter we will elaborate how the knowledge of Wageningen University and Research centre can be applied in such projects.

4. Opportunities for Wageningen UR

Introduction
Wageningen UR exists since 1876 and is internationally well known for its expertise on agriculture. The institute offers courses to more than 10,000 students and employs over 6,000 employees. The annual turnover is almost € 700 million euros. During the second half of the 20th century this agricultural expertise has been developed further into a much broader perspective. Since 2007 the domain consists of three interconnected core areas. The first area is health, lifestyle and livelihood. It focuses on people's behavioural choices regarding health, food and living environment. The second area is food and food production. This area concentrates on production and supply in the food chain, such as sustainable agriculture/horticulture and fisheries/aquaculture and the use of biomass within the scope of a bio-based economy. The last area focuses on living environment. Important themes include nature, landscape, land usage, water and ocean management, and the various competing claims on space. The combination of these domains form the basis to explore the potential of nature to improve the quality of life. The innovative and integral approaches of Wageningen UR are illustrated below by a number of best practices from the rich yield of research (Wageningen UR 2009a & 2009b).

Metropolitan Food Clusters
Since 2000 researchers from Wageningen UR work at the concept of Agroparks, along with other scientific institutes, governments, businesses and civil society. Metropolitan agriculture in the form of Agropark development includes a system innovation in modern agriculture with fundamental innovation in agro-logistics and trade, advanced industrial agricultural production, food processing and regional development of the agricultural system play a role, it's not just about innovations in agricultural production itself but also other relationships between stakeholders. Agro Parks are part of what is called 'Metropolitan Agriculture', which can be defined as a system of sustainable agricultural production with the ambition to meet the changing and competing demands of urban society has to set. This is achieved through new and intelligent links, specific to the network society in which we live. It is not just about connections between producers, sectors, commodities, energy and waste, but also links between stakeholders and their different value systems. In metropolitan agriculture, the one hand the opportunities that a highly urbanized area simply offers to use sustainable agriculture and by contributing to a more sustainable development of urban areas.

An agricultural park is located in a metropolitan area and is a spatial cluster of agricultural functions and related economic activity. There are high-yielding crop and livestock production and processing site on an industrial scale, with logistics, trade and use of a knowledge and technology. Within the clustering of various chains, the cycles of water, minerals and gases in a smart way closed and the use of fossil energy minimized, particularly by the processing of different flows and residual products. An agropark can thus be viewed as the application of industrial ecology in the agricultural sector. The aim is to achieve agro parks in cities around the world. The agro parks to each other and with local and global markets, connected in a 'Agrologistics Intelligent Network (IAN). Agroparks form a new link in the food value chains between consumers in urban markets and suppliers of raw materials: they bring transformation in the (rural) agricultural production, as in the agro-logistics and trade effects. To primary production for the supply of raw commodities innovative and appropriate reform is a necessary regional transformation. In developing countries (India, Asia, China. Africa) is more than agrarian

reform, it also touches on sustainable regional development in its socio-economic and environmental aspects.

Building with Nature

Objectives
This research project uses the concept of ecosystem engineering to investigate the potential use of biogenic reefs in the lower intertidal zone for consolidation and stabilization of tidal flats in the Dutch Delta region. The project will provide the means to evaluate the effectiveness and impacts of an innovative and sustainable approach to reduce erosion of intertidal areas.

Approach
Field experiments have been set up at a scale that allows us to really monitor the effectiveness and impact of biogenic reefs for the stabilization of tidal flats and for their eco-morphological impact. For this purpose we follow different steps that allow us to successfully design such pilot experiments: initial conditions for settlement and development of oyster reefs; development of suitable substrates for creating optimal conditions for biogenic reef development in tidal areas; large-scale pilot to investigate possibilities to create biogenic reefs in the Dutch Delta region and evaluate their effectiveness for consolidation and stabilization of tidal flats; monitor pilot sites to determine their effect on the environment both physically and biologically; develop tools/models to evaluate the use of biogenic reefs.

Results
A habitat suitability model is has been made that generates prediction maps where potential habitats are situated for setting up biogenic reefs. Testing of artificial substrates at a small scale is running and a first pilot experiment has been carried out in 2009. A large-scale pilot has been executed in 2010.

Follow up
The ecosystem engineer concept offers promising opportunities for eco-dynamic design, but has yet to be formally and explicitly applied. Identifying and managing probable engineering species and responsive ecosystems should be a key priority for a sustainable conservation and management and this will necessitate a shift to a process based understanding of the functioning of whole systems, which is a large and important step toward ecosystem-based management. This pilot experiment will enhance our understanding about the use of ecosystem engineers in this eco-dynamic design.

Funding
Building with Nature is managed and administered by the EcoShape Foundation. The program aims at developing new design concepts for the layout and sustainable exploitation of river, coastal and delta areas.

Partners
This project is realized by a multidisciplinary project team with scientists from IMARES-WUR, Deltares, NIOO and Van Oord.

Environmental Risk Management System

Objectives
The Environmental Risk Management System is a four year research program initiated by the Norwegian oil industry. The objective is to develop an environmental risk-based decision supporting tool. With this tool, cost-effective mitigation measures are established for reducing potential harmful discharges of the offshore oil and gas industry to the marine environment.

Approach
Following the Norwegian authorities' requirements in 1997 of "zero discharges to sea" within the end of 2005, the operating companies on the Norwegian shelf initiated the development of a modelling tool used for guidance of management decisions for reduction of potential harmful environmental effects associated with produced water discharges. This effort was embodied in the DREAM (Dose-related Risk and Effect Assessment Model) project, from which the Environmental Impact Factor for produced water (EIFPW) was developed.

Results
The EIFPW was developed as a management tool to be applied by the oil industry. Its calculation is based on internationally agreed procedures for hazard and risk assessment, as defined by the European Union, including the PEC/PNEC ratio approach. This approach compares the Predicted Environmental Concentration (PEC) of a pollutant with the predicted environmental tolerance level or the concentration below which the likelihood of adverse effects in the environment is considered to be acceptable.

A three-dimensional, time variable concentration field is modelled for each of the produced water compound groups as input to the PEC/PNEC calculation and EIFPW determination. Both the fate modelling and the risk modelling are carried out by the DREAM computer model. A major data collection study was performed as part of the development of DREAM to obtain data of sufficient reliability to be selected for determination of PNEC values. The establishment of PNEC values was based on the principles described in the EU Technical Guidance Document (EC, 1996 and 2003). The EIF approach, implemented in DREAM, has proven to be very useful in decision-making on implementation of produced water treatment techniques and the use of offshore chemicals and represents the state of the art in marine water column risk assessment tools. Consequently an EIF for drilling discharges was developed as well, to evaluate the overall risk of both toxic and non-toxic stressors.

Funding
Norwegian oil and gas industry

Partners
RF-Akvamiljø, Akvaplan-niva, Battelle, MUST AS, SINTEF, UiO

Offshore Wind Parks - Windspeed

Objectives
Offshore wind energy deployment can significantly contribute to increasing the share of renewable energy in Europe's energy mix. However, competing uses of the sea, costs, grid integration and other barriers are important challenges to the development of offshore wind. Windspeed aims to assist in overcoming these obstacles by developing a roadmap defining a realistic target and a development pathway up to 2030 or offshore wind energy in the Central and Southern North Sea (Belgium, Denmark, Germany, the Netherlands, Norway and the UK). The roadmap will also identify barriers and potential surplus conditions in the North-European electricity grid along with policy recommendations on how to tackle these.

Approach
Identify, collect and collate existing data. For nature aspects the following information was used:

- Nature Conservation Areas which are based on RAMSAR Convention, Bird Directive and Habitat Directive and Natura2000 sites.
- Benthos: based on a combination of benthic habitat maps for Germany, the Netherlands and Belgium, and extrapolated to the UK, Norway and Denmark by incorporating information on water depth and sediment composition.
- Fish: Species Richness: based on results for several years from the regular BTS and IBTS surveys.

Combine all available data and apply calculation rules to identify available areas for OWP. Some rules are set up for nature aspects are as follows:

- Nature Conservation Areas: No go for OWP
- Benthos: low, medium and high: go; very high: negotiable
- Fish species richness: 'No go' for areas with highest fish biodiversity (>40 species) to preserve, negotiable (but widely available) for areas with 30-40 species, go for the remainder.

Calculate of Levelized Production Costs. Based on cost assumptions for a wind farm size of 600MW, Levelized Production Costs (LPC) are calculated for each 5x5km² grid cell.

Results
By combining all data and applying the calculation rules three categories can be identified: 1) areas that are restricted by nature conservation constraints and by high fish species richness, 2) negotiable areas having less fish species richness and very high Benthos values, and 3) remaining areas that are generally suitable for OWP. The figure below shows all negotiable as well as suitable areas together with their corresponding Levelized Production Costs for OWP.

Funding
The Windspeed project is supported by the Intelligent Energy for Europe (IEE) programme.

Partners
Energy research Centre of the Netherlands (ECN), German Aerospace Center, Garrad Hassan & Partners Limited, SINTEF Energy Research, German Offshore Wind Energy Foundation, Coventry University Enterprises Ltd, SPOK ApS, We@Sea

Green Shipping

Objectives
Our Green Shipping programme CUMULEO-MARITIME assists the world-wide maritime sector in applying an integral approach to work towards more sustainability. The programme enables companies to prioritise new sustainable design options during the process of shipbuilding or renovations of existing ships.

Approach
The essence of the approach is broader than merely a focus on emissions such as anti-fouling, ballast water, underwater noise, CO2, NOx and SOx . Moreover, the question is which emissions cause the greatest impact on our ecosystems. Therefore the methodology links maritime activities with ecosystems by looking at pressures that are caused by emissions. Calculations on emissions are linked to ecosystem components with dose-effect relations. This results in a benchmark providing an overview of the involved emissions and their effects on ecosystem components.

Results
Within the programme IMARES and SMIT International worked on the E3 Tug project, focussing on gaseous emissions. The modelled operational ship emissions clearly showed which configuration provided the highest reduction of environmental impacts. It appeared that NOx and SO2 are the major contributors to local environmental impact, while CO2 is the major contributor to global impact.

Funding
The CUMULEO-MARITIME programme is funded by the European Fund for Regional Development. It is co-financed by private companies in the maritime sector, such as SMIT International.

Partners
Maritime Campus Netherlands, TNO, SMIT International, Damen Shipyards Group

Spatial Planning and land use

Wageningen UR has a long tradition in spatial planning and all elements that are required to do this in an integral and sustainable way. GIS data analysis, landscape design, planning, the juridical framework and governance are all vital parts in sustainable planning.

This tradition started in the 1950's with the development of basic mapping programs such as the national soil inventory and the geomorphological mapping. In combination with other thematic map information (GIS) applications have been developed for the green/natural domain in relation to functions such as agriculture, water management, infrastructure and recreation and in combination with spatial planning tools and knowledge on relevant laws. Recently, over the last decade social interaction with stakeholders has proven to be a conditional demand.

Examples of powerful tools and concepts are available and here we will briefly describe two examples.

Maptalk is a tool that is basically an interactive computer screen in the shape of a conference table. It combines relevant (GIS) data with all the participating stakeholders in a spatial planning process. Changes in land use can be evaluated on the spot for effects making this a powerful tool in participatory planning.
Ecological connectivity linked to land use is a concept that enables planning of a multifunctional landscape where all the different needs and demands are taken into consideration. This concept approaches land use or land use elements as parts of the landscape that can fulfill different functions; for example a line of trees can at the same time be of recreational, agricultural and ecological importance.

Additionally Wageningen UR has gained broad experience in policy analysis (government and governance issues) and knowledge on spatial laws both national and international (for example Natura 2000).

Wadden Academy

Objectives
It is the ambition of the Wadden Academy (chaired by scientists of the Wageningen UR) to develop the Wadden Sea Region into an incubator for widely applicable integrated knowledge of sustainable development of a coastal area, in which natural values are a key element and form the foundations of the local and regional economy. The region is a meeting place for scientists from the Netherlands and elsewhere, administrators, policy makers and management agencies. Together, they develop sustainable and innovative solutions based on interdisciplinary knowledge. By 2020, the trilateral Wadden Sea Region will be the best monitored and best understood coastal system in the world (Waddenacademie 2011a).

Approach
There is a substantial disciplinary knowledge base on the Wadden Sea Region, but – as indicated above – major gaps in this knowledge also remain. It is further noted that the existing knowledge and expertise is fragmented and compartmentalised. The lack of an interdisciplinary approach hinders the understanding of the Wadden Sea Region as a coherent and open system. In a systems approach, different elements, features and processes of a (linked natural and socio-economic/cultural) system are explicitly connected to one another. According to
the Wadden Academy, research can be described as 'integrated' if it satisfies the four criteria below (Waddenacademie 2011b):

- It shows a combination of two or more disciplines with the emphasis on crossing the boundaries between natural science, social science and humanities;
- It takes into account the interplay between processes at different temporal and spatial scales;
- It takes into account the accumulation of processes, interventions and impacts;
- It is based on the co-production of knowledge, where the formulation of knowledge demand, the production of knowledge and the use in management result from close interaction between scientists, government experts and policy makers

Results
More than 15 interdisciplinary publications on the development of the Wadden Sea.

Funding
The Wadden Academy is funded by the Dutch Wadden Foundation

Partners
National Water Research Center (Egypt), Eduardo Mondlane University (Mozambique), Wageningen UR (The Netherlands), Deltares (the Netherlands), Institute of Water Modelling (Bangladesh), World Wide Fund for Nature (China), Indonesian Institute of Sciences (Indonesia), Vietnam National University, World Wide Fund for Nature (the Netherlands), National Institute for Research and Development of Marine Geology and Geoecology (Romania), Arcadis (USA), Princeton University (USA), Tulane University (USA)

Delta Alliance

Objectives
Delta Alliance brings together actors such as centres of expertise, government bodies, non-governmental organizations, consulting firms and industry to tackle problems in an integrated way and to work collaboratively towards sustainable development. The central motivation for creating Delta Alliance is to provide a foundation and framework for successful international cooperation that will support more effective and efficient responses to increasing pressures in river deltas worldwide. Delta Alliance should provide a framework to support the symbiosis of the countless activities ongoing in delta regions, reducing unnecessary overlap and identifying gaps in efforts. Delta Alliance will be a vehicle for increased cooperation between parties in river deltas worldwide, with the ultimate aim of improving the resilience of the world's deltas through more integrated and effective efforts (Delta Alliance 2011a).

Approach
The strategy to realize the objectives and include the following points Delta Alliance (2011b):
- Envisioning and defining resilience for deltas
- Measuring and monitoring resilience
- Reporting and creating pressure for improved resilience
- Providing inspiration for improved resilience
- Providing assistance for improved resilience

Results
In order to improve the resilience of delta areas worldwide and to learn lessons from other deltas, Delta Alliance supports inter-delta projects. These projects focus on a minimum of two delta regions to allow people working in different deltas to learn from each other. The following projects under Delta Alliance are carried out so far, often in cooperation with other parties (Delta Alliance 2011c):
- Bandung Workshop
- DeltaCompetition 2010
- Comparative assessment of the vulnerability and resilience of 10 deltas
- Jakarta climate change adaptation tools
- Assessment studies for the Mekong Delta Plan

Funding
This project is funded by The Knowledge for Climate Programme of The Netherlands. It is co-financed by the involved partners.

Partners
National Water Research Center (Egypt), Eduardo Mondlane University (Mozambique), Deltares (the Netherlands), Institute of Water Modelling (Bangladesh), World Wide Fund for Nature (China), Indonesian Institute of Sciences (Indonesia), Vietnam National University, World Wide Fund for Nature (the Netherlands), National Institute for Research and Development of Marine Geology and Geoecology (Romania), Arcadis (USA), Princeton University (USA), Tulane University (USA)

Realising opportunities for sustainable development
In the previous sections major developments in the Arctic Region were identified. In addition some best practices from the yield of research from Wageningen UR were presented. This section explains how Wageningen UR contributes to sustainable development in the Arctic.

We have identified new opportunities for agro-production and logistics in the Arctic region. Especially for less developed areas in the Arctic region, Agroparks could provide new economic incentives. Agro clusters might also be developed in coastal areas, e.g. in combination with the fishery, aquaculture and tourism sectors. In some cases new harbours could be constructed that will be new clusters of economic activity. To realise these opportunities Wageningen UR can provide comprehensive knowledge on agricultural economics and development of Agroparks. Moreover our experience with plant, livestock and fish breeding will be essential for sustained development of agriculture.

In order to steer economic development spatial planning is of utmost importance. To achieve sustainability it is necessary to decide where activities might develop and where flora and fauna should be protected. These choices have to be based on profound knowledge of sectors and ecosystems. The involved stakeholders certainly have to be aware of effects of activities on ecosystems and how these effects can be reduced. This will offer them a licence to produce in a sustainable manner. Therefore models, tools and instruments for spatial planning will be necessary. Due to its experience with multi-disciplinary research, Wageningen UR combines its expertise to assist public and private partners in these developments.

As we have seen in the foregoing sections governmental organisations on local, regional, national and international levels are facing huge challenges to solve conflicts and create opportunities. To do this they need new policies, laws and regulations. The development of Integrated Coastal and Ocean Management for instance might be unavoidable. Countries such as Norway are making progress but other countries might have a lack of access to knowledge for the development and implementation of such complex processes. For many decades Wageningen UR has international experience with dealing with such complexities. This experience will prove to be highly useful for governmental organisations in the Arctic Region.

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